Memorandum on the Recurrence of Twig Blight at

Prescott, Arizona.

Recently an analysis of the records on the twig blight sample plots at Prescott was made primarily for the purpose of determining to what extent the disease tended to reappear on the same trees each year.

The data on which the following remarks are based include 4 years readings (1935-1938 incl.) on the 16 plots established under the direction of V. O. Sandberg formerly of the Division of Forest Pathology. The plots were selected at widely scattered points throughout the Prescott Forest and represent a variety of sites, aspects, stand types, and blight conditions. All plots except one have been subjected at one time or another to twig blight control work, and most of them have been cleaned at least twice.

Originally there were 1696 trees on the 16 plots but 23 of these have either died or been felled during the four year interval. The remainder of 1673 trees has been used as a basis for the calculations included in this memorandum. Few, if any of the 23 were killed by the disease.

The period 1935 to 1938 includes two light ('36 - 37) and two rather heavy ('35 - '38) blight years as can be seen from Table 1.

Table 1. - Blight intensity for the years 1935 - 1938 incl.

Year	Trees blighted		Blighted twigs	
	No.	% of Total*	No.	% of Total**
1935	338	20	2148	36
1936	107	6	253	4 +
1937	139	8	1097	18 +
1938	319	19	2466	41 +
Total	903	--	5964	100

*Basis: 1673 trees on all plots.
**Basis: 5964 blighted twigs for 4 year period as taken from Sandberg's report of 7/28/38.

Whereas there were 903 cases of trees being infected during the period, it is interesting to note that actually only 537 trees harbored the disease. Or possibly more pertinent; during the four years, 1136 (nearly 68%) of the 1673 trees on the plots remained absolutely free from blight.

Table 2 shows the extent to which blight has tended to recur on the same trees. The number of diseased trees

Table 2. - Recurrence of blight on the same trees.

No. Years Blighted	No. trees	% of Total	% of Blighted trees
Blighted 1 year only	293	17.5	54.6
" 2 years	149	8.9	27.7
" 3 years	68	4.1	12.7
" 4 years	27	1.6	5.0
Total	537	----	100.

appearing in any one year which previously or thenceforth did not have the disease, seems to be quite closely correlated with the blight intensity for the year of their appearance. This is brought out in Table 3, e.g. in 1935, 20% of all trees were blighted and of these 42% were infected only in 1935, whereas in 1936 only 6% of all trees were blighted and of these only 10% were infected that year only.

Table 3. - Relation of trees blighted 1 year only to annual blight intensity.

Year	% Infection	% of blighted trees diseased that year only
1935	20	42
1938	19	37
1937	8	16
1936	6	10

These data suggest that heavy blight years are characterized by a marked spread to new trees most of which are not affected in subsequent light blight years. A consideration of the relative intensity of flagging in this connection is given in Table 4 which shows that 47% of the

flags appearing in 1938 occurred on trees which had been blighted in 1937. The latter comprised 37% of the total number of trees blighted in 1938 and showed an average of 9.7 flags each. The remaining trees blighted in 1938 but not in 1937 had only an average of 6.6 flags each. This suggests that flagging is heaviest on trees which have been blighted two or more successive years. The average number of 1938 flags on the 27 trees which were blighted all four successive years was 10.3 each, which suggests again that the degree of flagging on a tree in any one year is directly correlated with the number of years it has been successively infected.

Table 4. -

Flagging on 1937 and 1938 blighted trees.	NO.	%	Flags per tree
1938 Flags (total)	2466	100	
1938 Flags on trees blighted in 1937	1135	46.0	
Trees blighted 1938	319	100	7.7
Trees blighted 1937&1938	117	36.7	9.7
Trees not blighted 1937	202	63.3	6.6

The points of this table when plotted on regular cross section paper lie almost in a straight line having approximately the formula $Y = 0.5X+0$.

A comparison of actual infection percentages with the probable percentages expected if infection were strictly random is shown in Table 5. The "expected percentages" shown are the quantities to be expected if there were no natural tendency for the disease to recur on previously infected trees. That this is not the case, i.e. that there is a strong tendency for flags to reappear on the same trees is brought out by the general trend shown in the table and emphasized by the fact that the trees infected 3 and 4 years in succession are 58 and 79.5 times greater respectively than the expected values. This is not surprising, in fact it is the usual tendency exhibited by most forest tree diseases, whether of an annual nature such as twig blight, or a perennial one such as white pine blister rust.

Table. 5 - Comparison of number of trees actually infected with expected percentage if infection were random.

When infected	Actual %	Expected*%	Difference Actual	Difference % of Expected
Never infected	67.90	56.04	+11.86	+21.16
Inf. 1 year only	17.51	35.60	-18.09	-50.81
Inf. any 2 years	8.91	7.69	+ .78	+10.14
Inf. 2 years in succession	2.93	2.34	+ .59	+ 25.21
Inf. any 3 years	4.06	0.65	+3.41	+524.62
Inf. 3 years in succession	1.02	0.15	+ .87	+ 580.00
Inf. 4 years	1.61	0.02	+1.59	+ 795.00

*Expectancy was calculated as follows:

Since infection in 1935 was 20%
" 1936 " 6%
" 1937 " 8%
" 1938 " 19%

Then $p_1 = 20\%$ and $q_1 = 80\%$
$p_2 = 6\%$ $q_2 = 94\%$
$p_3 = 8\%$ $q_3 = 92\%$
$p_4 = 19\%$ $q_4 = 81\%$

And the expected percentage of infection for:

1935 = $p_1 \cdot q_2 \cdot q_3 \cdot q_4 = I_1$
1936 = $q_1 \cdot p_1 \cdot q_3 \cdot q_4 = I_2$
1937 = $q_1 \cdot q_2 \cdot p_1 \cdot q_4 = I_3$
1938 = $q_1 \cdot q_2 \cdot q_3 \cdot p_4 = I_4$

And $I_1 + I_2 + I_3 + I_4$ = expected percentage of trees infected 1 year only.

Similarily $I_{1-2} = p_1 \cdot q_2 \cdot q_3 \cdot q_4$
$I_{1-3} = p_1 \cdot q_2 \cdot p_3 \cdot q_4$

And $I_{1-2} + I_{1-3} + I_{1-4} + I_{2-4} + I_{3-4}$ = expected percentage of trees infected for any two years; and so on for 3, and 4 years, or successive years as desired.

The small, basis for these data, the relatively short period over which observations have been made, together with the fact that control operations have probably disturbed the natural course of the disease hardly warrant drawing even tentative conclusions from the figures at hand. However, their most interesting and significant indications might be summarized as follows:

1) Twig blight shows a tendency to recur on the same trees, year after year.

2) The intensity of flagging on a tree for any one year seems to be directly proportional to the number of years the tree has previously harbored the disease.

3) Heavy blight years are characterized by an abnormally heavy spread of the disease to new trees on which it fails to reappear during subsequent light blight years.

4) In the past four years the mortality due to twig blight has not been alarming in the plots studied.

5) In the past four years, nearly 68% of the trees studied have remained absolutely blight-free.

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